

# What foods do desert tortoises need?

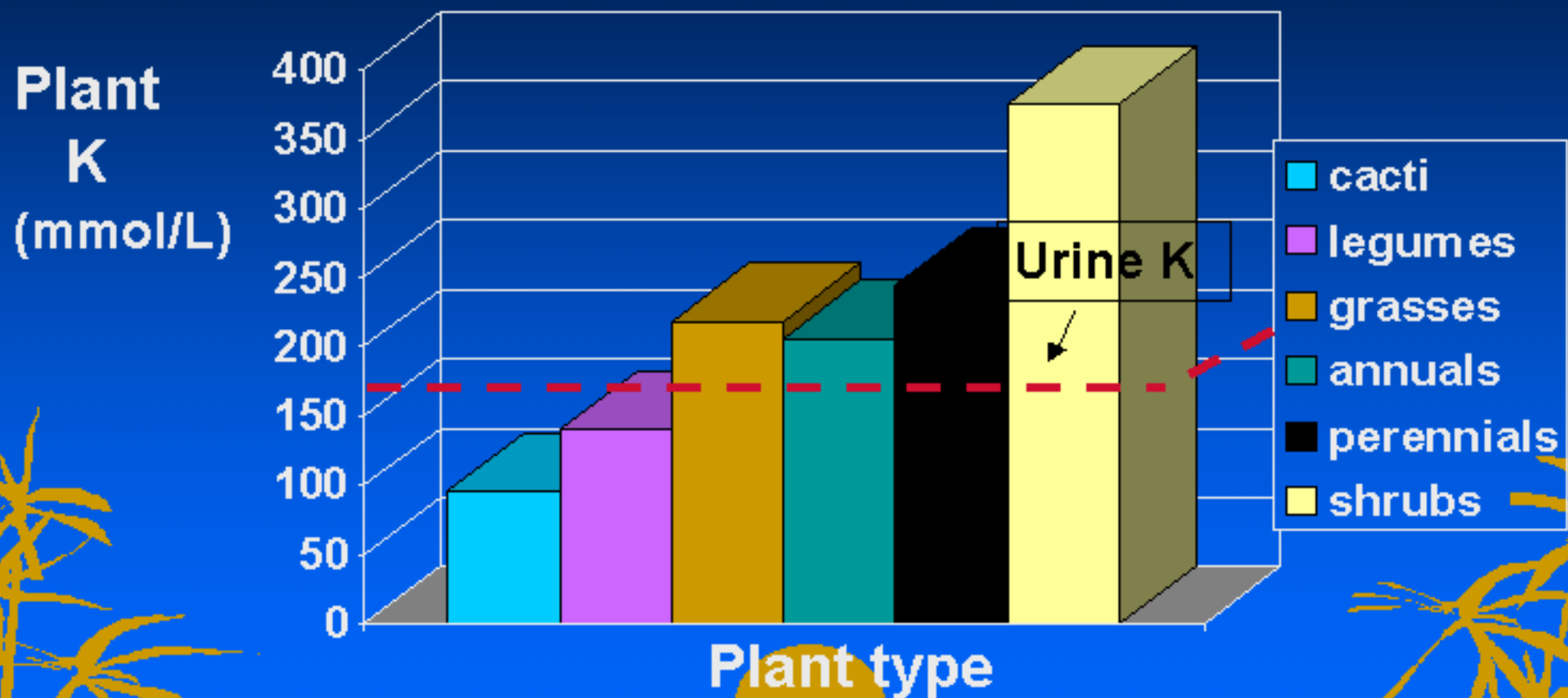


# Tortoises as unique herbivores

- Tortoises eat plants with excess potassium
- Unlike mammals and birds, cannot produce concentrated urine
- Unlike herbivorous lizards, cannot produce salt secretions from salt glands
- How do they do it?



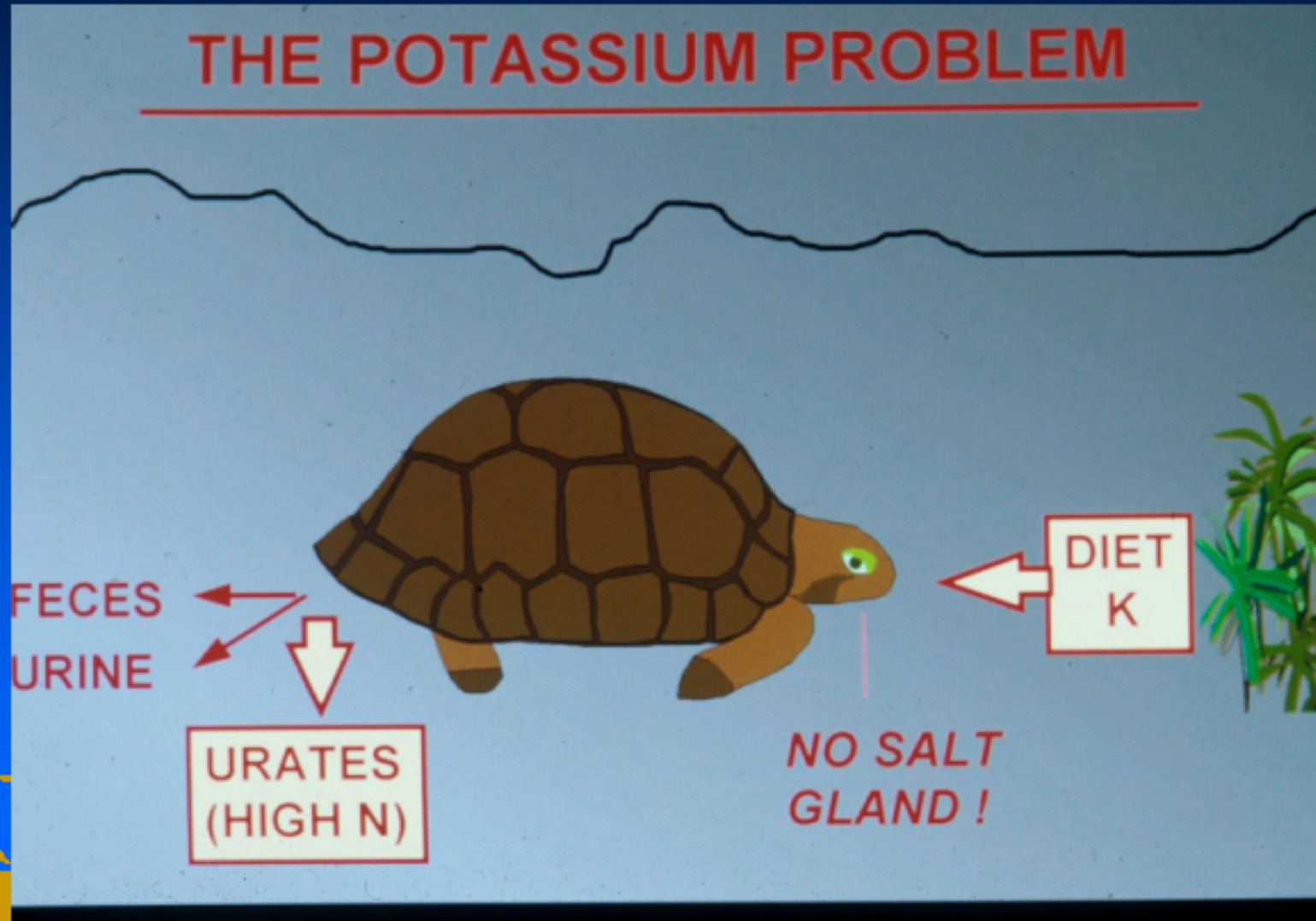
# Potassium in Mojave Desert Plants\*



\*Samples collected in 'wet' years only



# K excretion requires N



# Nitrogen Intake and Excretion on diets of different potassium %

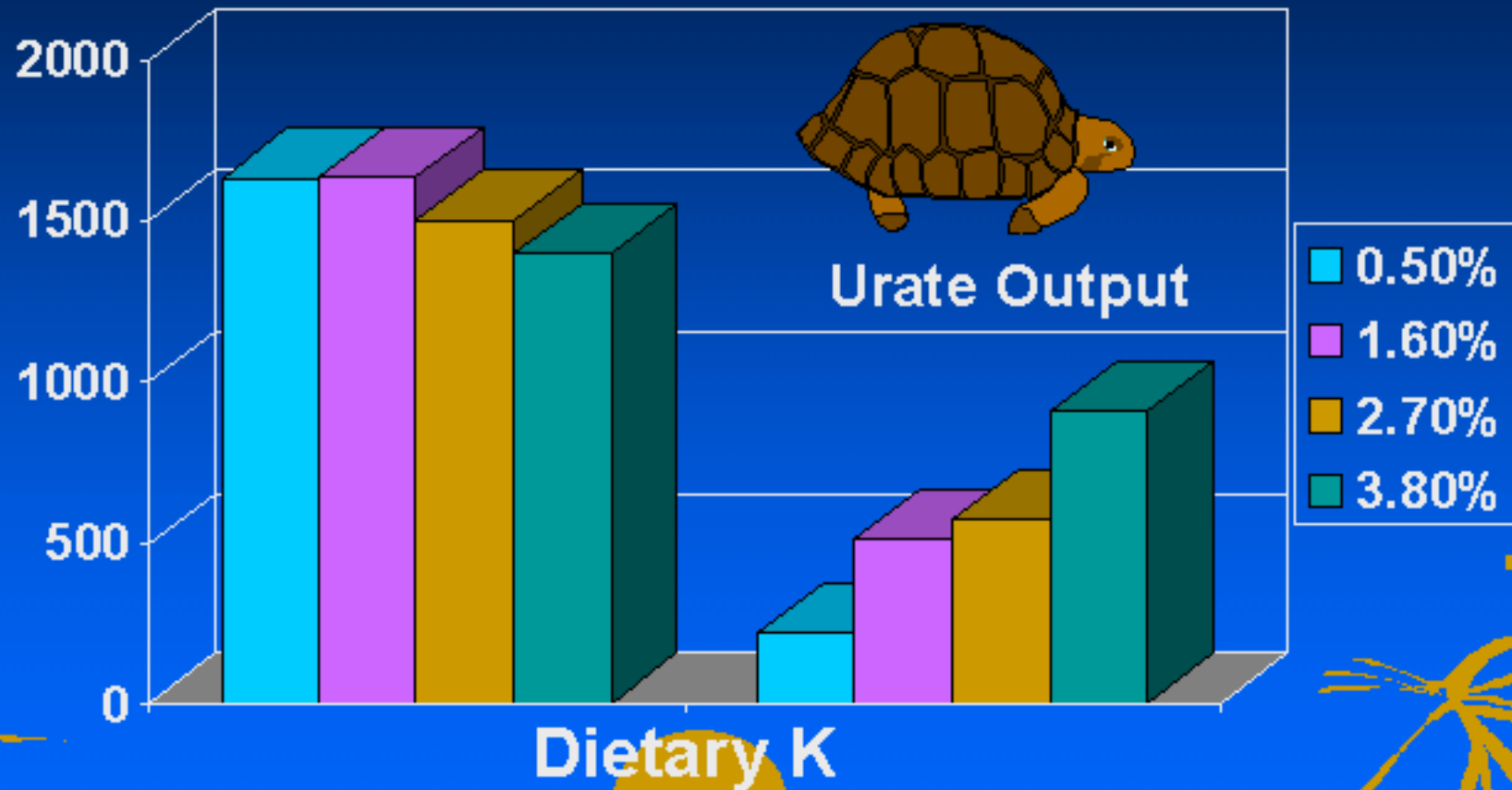
Intake

Dietary N = 3.2%, Urate N = 26%

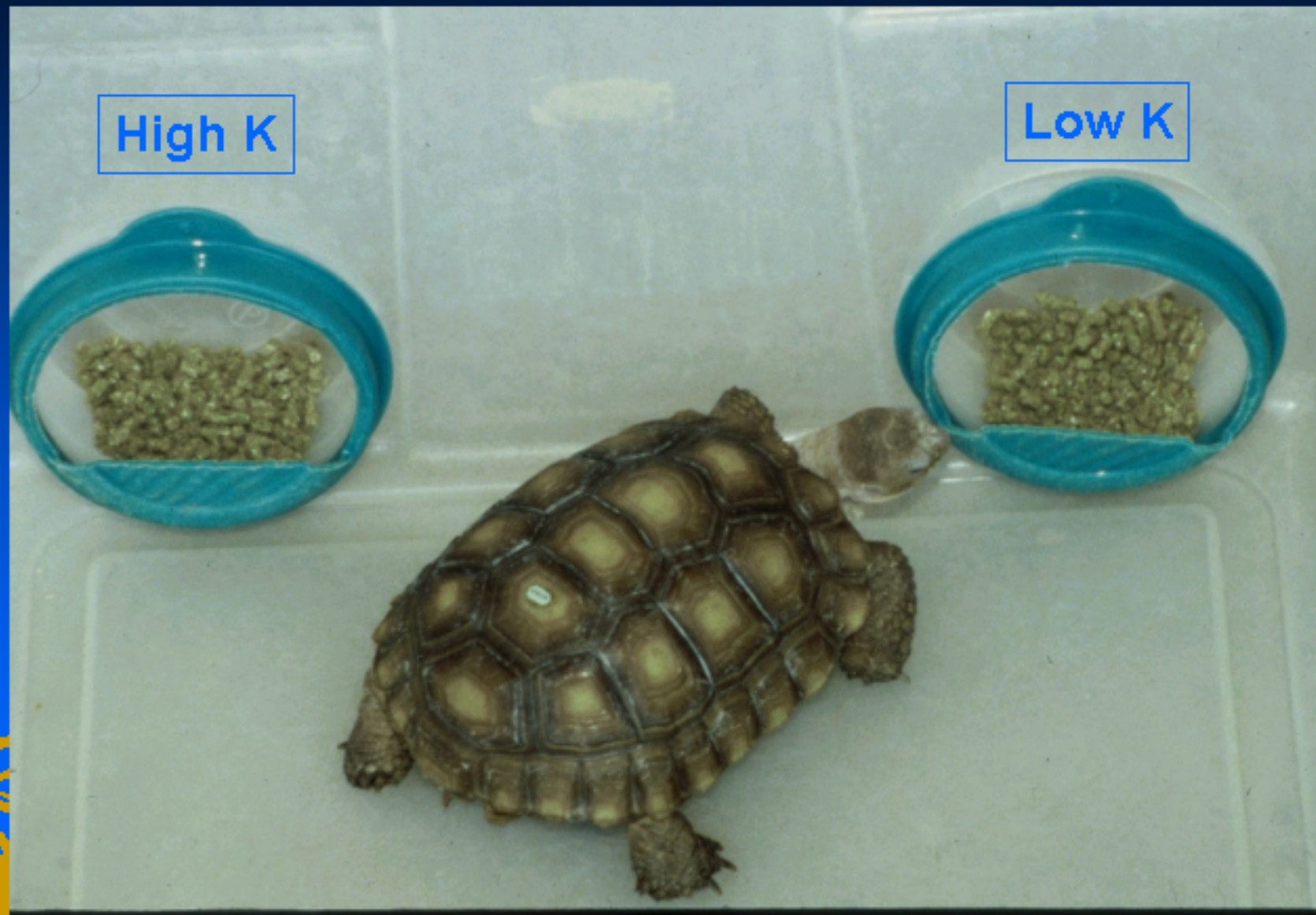


Urate Output

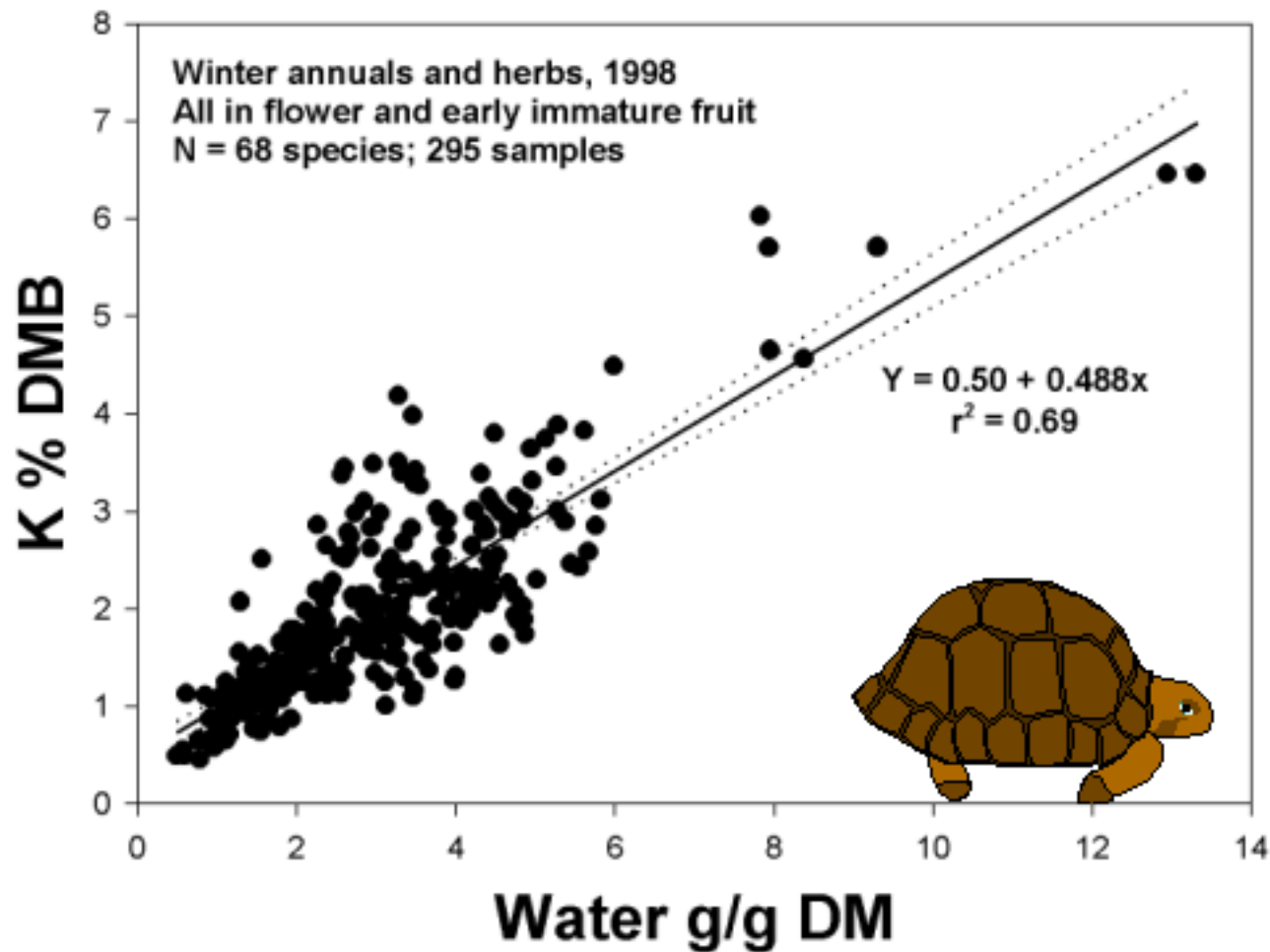
N  
(mg/  
kg BM)



In choice trials, tortoises avoid K



# Potassium vs. water in spring forage



Desert Tortoise Research Natural Area, Kern Co., CA





# The **PEP** Index of food quality

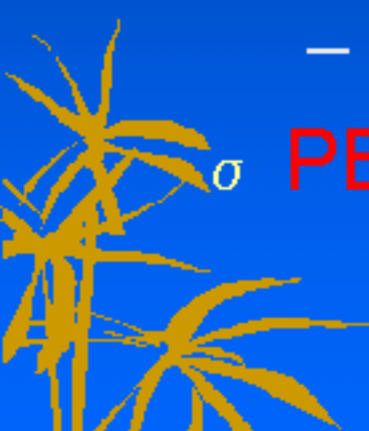


σ Calculate the net **p**otassium **e**xcretion  
**potential** for ingested food

σ Assumptions

- All  $H_2O$ , N, K absorbed and can be excreted
- Urine of maximal K content (6.5g K/kg  $H_2O$ )
- Urates of maximal K content (K:N ratio of 0.61:1)

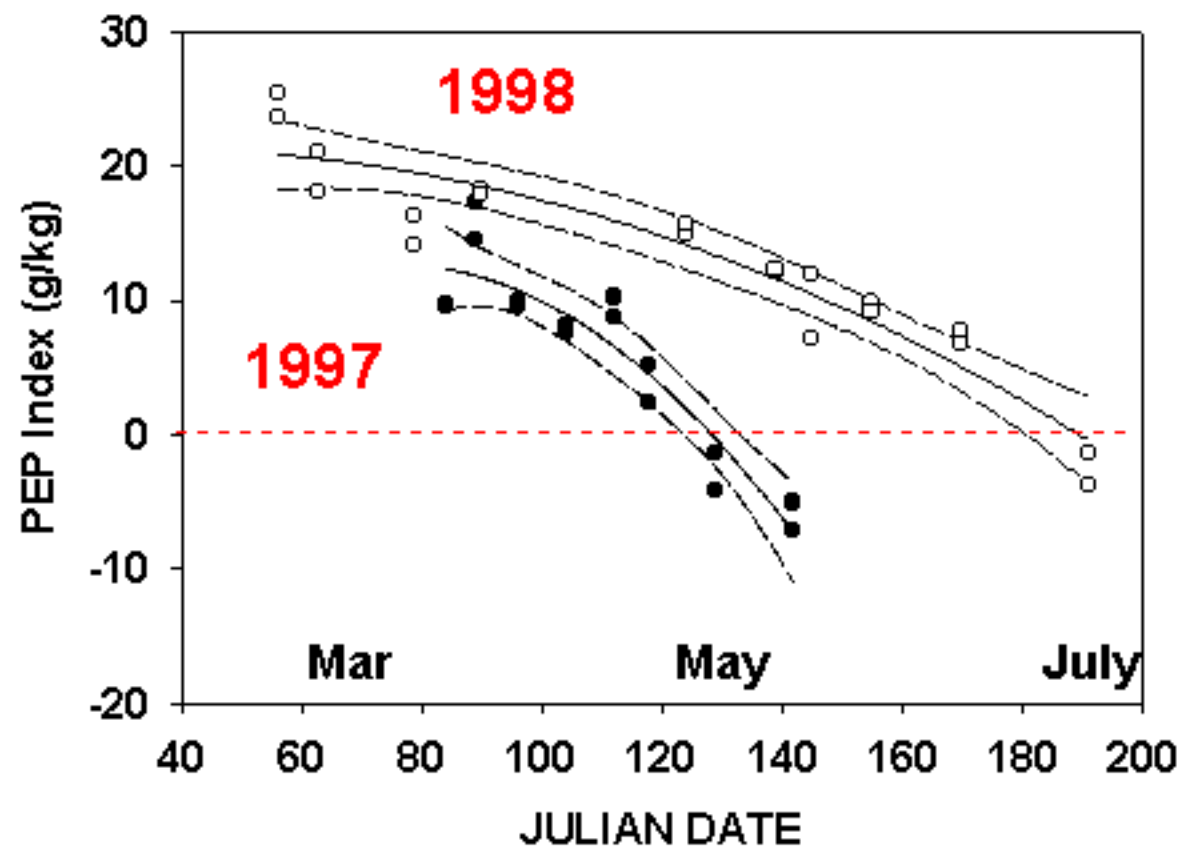
σ **PEP** (g/kg) =  $6.5 * H_2O \text{ g/g} + 6.1 * \%N - 10 * \%K$





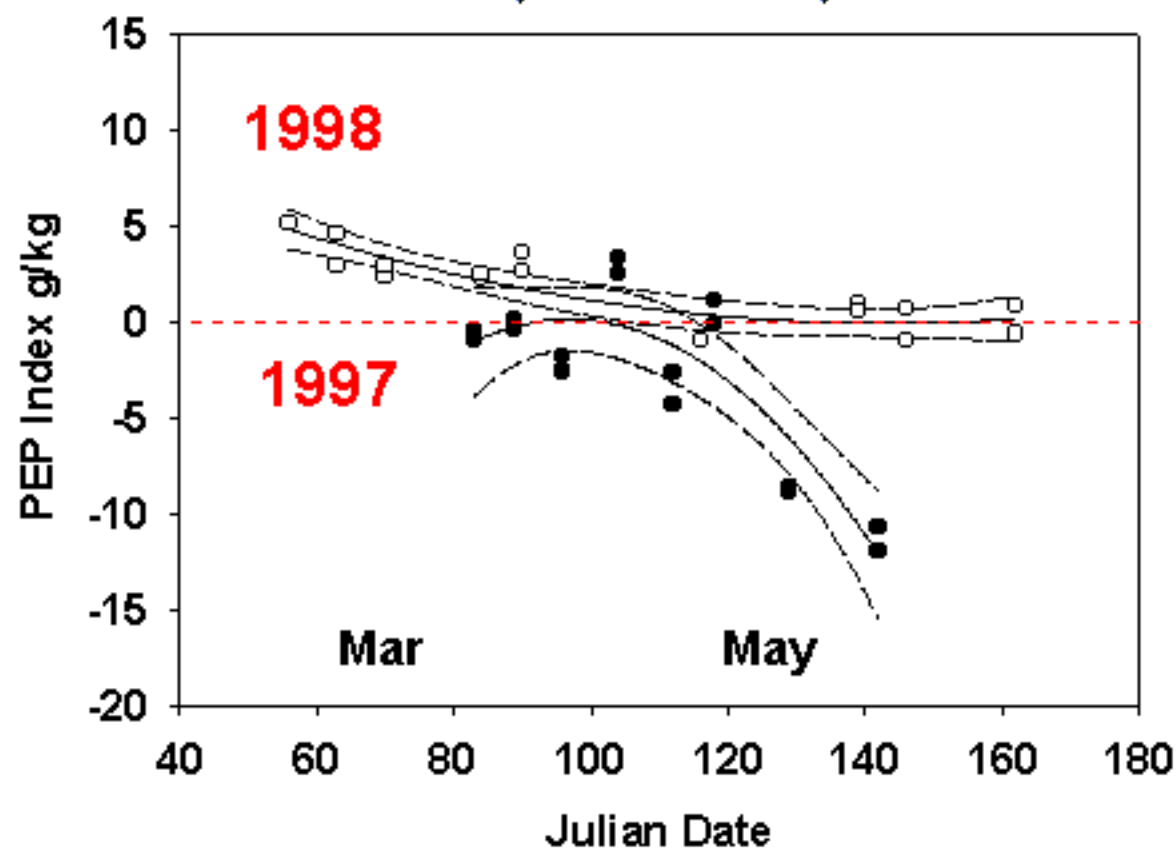
# *Camissonia boothii*

DTNA, Kern Co., Ca



# *Cryptantha circumscissa*

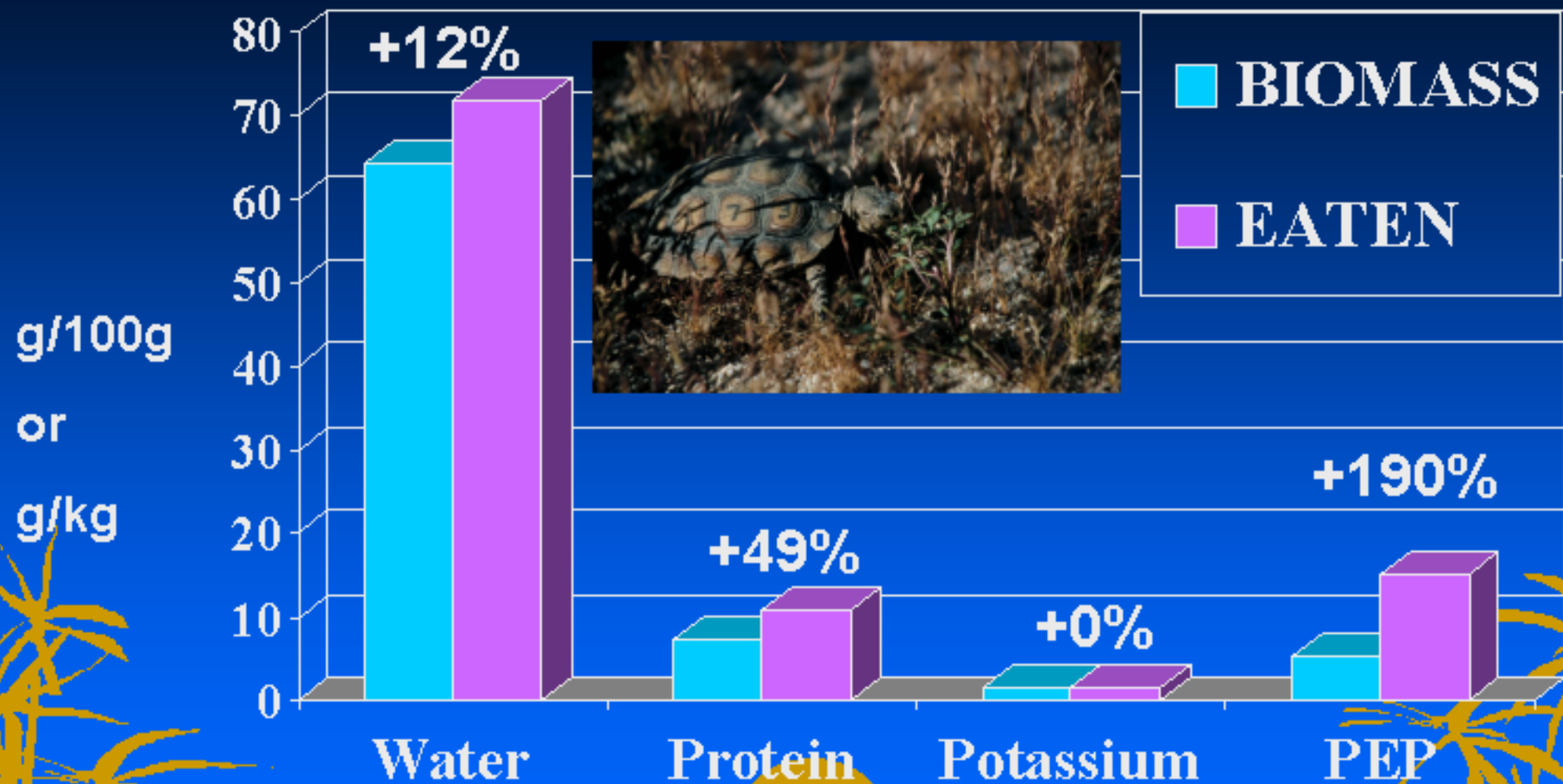
DTNA, Kern Co., Ca



# Foraging choice at Ft. Irwin Study Site



# Diet selection - foraging juveniles



Fort Irwin Study Site, April 1998 - Oftedal, Hillard & Morafka 2002



*Camissonia  
claviformis*



## What types of plants are high in PEP?

- σ Annuals with high protein content associated with high photosynthetic rate (Rubisco)
- σ High photosynthetic rate involves a lot of transpiration (water loss)
- σ Limited K accumulation in vacuoles
- σ Germinate in high rainfall years, as require high soil moisture (water potential)
- σ Most years remain in seed bank



# Plants available varies by year

- σ In drier year, choice is among range of low PEP plants
- σ High PEP plants only in wet years
- σ Even in high rainfall years, high PEP plants can be scarce



*Cryptantha*



*Camissonia*

- σ In 1992 tortoises in W. Mojave searched out and ate scarce high PEP plants such as *Astragalus*, *Lotus* and *Camissonia* (Jennings 1993)



*Lotus*



# Cattle grazing affects high PEP plants

- In Ivanpah Valley, CA cattle outside exclosures removed high PEP plants, leaving lower PEP plants for tortoises.

## Estimated PEP, tortoise diets

	Ungrazed	Grazed
Early spring	21	11
Late spring	9	2



Data of Avery 1998, as calculated by Oftedal et al. 2002

# What has been the long-term effect of historic grazing?

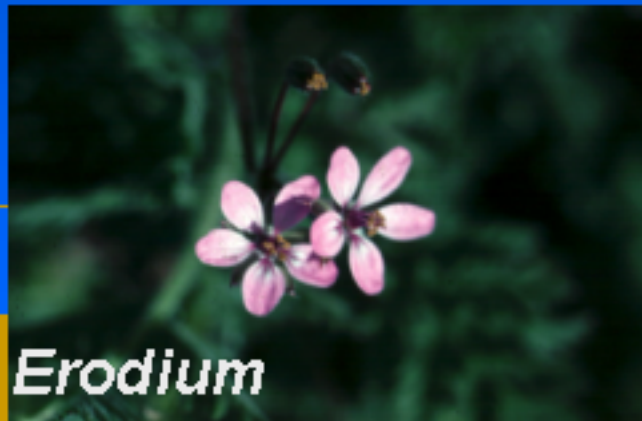
- σ Maximal grazing before 1940s
- σ Effects on perennial plants documented
- σ Changes in abundance of annuals?
  - Repeated “insult” to specific species?
  - Cumulative over time?
  - Changes in seed banks?





# Environmental change and invasive species

- σ Soil compaction, wind erosion, pollution, fire
- σ Very high density of invasive exotics
  - FISS 1998 *Schismus* 72% of biomass, 98% of individual plants
- σ Must account for much of evapotranspiration
- σ Competitive effect on high PEP plants?



*Schismus*



# PEP Shortage Hypothesis



- Desert tortoises in much of Mojave Desert experience a chronic shortage of essential nutritional resources (high PEP plants).
- This shortage leaves these populations particularly susceptible to disease, mortality, and density-dependent population crashes
  - 80% mortality events over a few years



# Management actions

- Eliminate grazing in high rainfall years to protect high PEP species
- Curtail invasive exotic plants
- Restoration/seeding to include high PEP species:

Legumes - *Astragalus*, *Lotus*, *Lupinus*

Evening primroses - *Oenothera*, *Camissonia*

Desert dandelion - *Malacothrix*

*Astragalus*



# Acknowledgments



## σ Funding:

- BLM (Las Vegas)
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- The Christensen Fund

